Mobile application for the control process of childhood anemia in time of the pandemic

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ABSTRACT

The objective of the research was to implement a mobile application for the control process of childhood anemia in times of pandemic, in order to have better medical control with faster care, better control of the diagnosis of anemia in children, and better performance and satisfaction. The following Scrum method was applied. The research has a quantitative approach, of experimental type. The sample consisted of 40 children. Results were obtained regarding time control in the speed of care, an increase of 10.2% was obtained; regarding the number of diagnoses, control, and follow-up in recovery there was an increase of 33.3% and finally regarding the control of performance and satisfaction with care there was an increase of 73.3%.

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1. INTRODUCTION

Currently, anemia is a serious public health problem in the world that particularly affects children [1] estimated that 614 million women and 280 million children are still affected by anemia worldwide; Iron is an element with important essential functions such as deoxiribo nucleic acid (DNA) synthesis, oxygen transport, and muscle metabolism. Iron deficiency is the main cause of anemia, the most prevalent nutritional deficiency worldwide: it affects 33% of non-pregnant women, 40% of pregnant women, and 42% of children. Research by Garibay [2] indicates in his article that the population affected by anemia in industrialized countries are pregnant women (18%) and preschoolers (17%), while in developing countries those who suffer most from anemia are pregnant women (56%), schoolchildren (53%) and preschoolers (42%). Anemia is considered a disease that does not show alerts, remains silent in children, and is a social problem affecting an average of one-third of the world population. Research by González-Martell *et al*. [3] The article states that low stature and nutritional deficiencies in Mexico are more prevalent in vulnerable low-income populations. At the national level of Peru, the prevalence of anemia in the population from 6 to 35 months of age was 40.0%, registering a higher incidence in rural areas (48.4%) than in urban areas (36.7%) in the year 2020 [4]. The prevalence of anemia in children from 1 to 5 years of age in 2017 was 38.5%. A significant association was found between certain sociodemographic factors such as area of

residenc [5]. On the other hand, inadequate food consumption often causes anemia problems that lead to the acquisition of diseases and sudden death. From this perspective and considering that food insecurity is a current and multifactorial problem, which causes great concern worldwide due to its close relationship with high mortality rates [6]. Which is a serious hematological disorder, where affected patients are frequently hospitalized throughout life and can even cause death [7]. For this reason, the daily consumption of micronutrients can change the lives of children. Administering them for a year in their meals guarantees their physical and emotional development, expanding their work and academic options and protecting them from anemia [8].

Likewise, through images, you can also detect diseases such as anemia. A method was proposed to recognize images of normal and abnormally shaped red blood cells using the shape factor, perimeter, and area as feature descriptors [9]. Also, the design of a finger probe for non-invasive diagnosis of anemia in children, had a satisfactory result, for which several tests were performed, in which the detection of anemia depended basically on blood cells [10].

It is indicated that the main cause that leads to anemia is lack of iron, the biomarker is a key point that will help guide and evaluate measures to combat it. Anemia usually occurs when the body does not have enough red blood cells. Red blood cells will not be able to carry oxygen when your hemoglobin is too low it will start the effects like feeling fatigued, dizziness, pale, and skin. As in schools, awareness about the prevention of diseases such as anemia should be increased. Therefore, in the [11] details as a preventive measure, an education program on anemia in schools should improve the knowledge of students about the consumption of iron tablets [12].

The objective is to build and validate the technology used for COVID-19 and essential care in children/adolescents with sickle cell anemia, the results obtained were that the educational technology "sickle cell disease and COVID-19: essential care" included: the consequences of COVID-19 in sickle cell disease, measures to reduce the risks of contracting the virus and its complications, symptoms, and signs of COVID-19, guidelines in case of a child/adolescent with suspected COVID-19 or symptoms of COVID-19 [13]. Global content validity coefficient (Delphi II): 0.98; therefore, it was concluded that educational technology presents content and appearance validity for families of children/adolescents with sickle cell anemia, related to COVID-19. The goal is to create a novel multi-wavelength detection spectrophotometry platform to detect anemia [14]. The results of the Hb values predicted by the algorithm were compared with automated cell counters based on standard invasive methods. Research by González *et al.* [15] aimed to characterize the biochemical and clinical alterations in children undergoing preventive and curative treatment of anemia under one year of age. According to the hemoglobin figures (15.2%) of the 315 patients studied, 48 were diagnosed with mild anemia. All patients have been prescribed treatment with for-fer (200 mg ferrous fumarate and 1 mg folic acid) and food hygiene. The 48 anemic patients, in addition to specific treatment for anemia. After six months of treatment, the hemoglobin values of both groups increased and were similar, only one child had low hemoglobin values. The increase in hemoglobin had a mean value of 20.25 g/l in anemic children and 6.95 g/l in non-anemic children. The conclusion the patient's preventive treatment with the supplement For-fer allowed them to reach normal hemoglobin values for age. The objective was to review the different opportunities for the application of "information and communications technology" to strengthen the fight against anemia [16]. The objective was to determine the behavior of hemoglobin according to altitudinal floors, in Peruvian children, with the purpose of proposing a national correction factor, the results were compared to the prevalence of anemics diagnosed with the proposed correction factor against the one traditionally used by the centers for disease control and prevention (CDC) [17]. The differences at the national level reached 2.5%, being more marked above 3,000 masl, with 9.2%. The departments with differences of 5 percentage points and more were Puno (12.7%), Huancavelica (9.9%), Apurímac (7.8%), Pasco (7.4%), Ayacucho (6%), Cusco (5.7%) and Junín (5.6%), in conclusion, the proposed correction factor identifies a lower prevalence of anemia than the factor traditionally used, and this is based on the greater differences that occur from 3,000 masl. Research by Cabanillas-Carbonell *et al.* [18] explain that with this implemented tool that is the mobile application; the doctor according to the hemoglobin, age, sex, and condition of the patient automatically assigns in the application a light or rigorous diet to follow daily until the next control and thus reflecting in the application calendar the foods to be consumed by the patient, the patient will indicate their daily consumption and the application will playfully show compliance with their treatment on their calendar. As a result, in a study conducted in a clinic in the city of Lima, regarding the acceptance of the usability of the application, in a sample of 150 patients with anemia, 93.1% were satisfied. It is concluded that the mobile application for monitoring and controlling the diet in people with anemia helps assign a diet automatically and efficiently, showing an improvement in each control. In the following investigation [19], the objective is to determine the prevalence of vitamin A deficiency (VAD) and nutritional anemia (AN), in children under five years of age in Peru, the results the prevalence of VAD was 11.7% (95% CI): 9.4-14.4). The prevalence of AN was 33% (95% CI: 29.9-36.1), being higher in children under 11 months (68.2%) and children of mothers between 13

and 19 years of age (55.4%). In conclusion, children living in rural areas and in the jungle are the most affected. A slight improvement in the prevalence of AN is observed. The impact and efficiency of iron and vitamin A supplementation programs should continue to improve.

2. RESEARCH METHOD

In the present investigation about a mobile application for the control process of childhood anemia in times of the pandemic, the Scrum method is chosen for software development, because it is the one that best suits the times, the size of the project, and costs. Scrum is a framework that provides a series of rules and specific tasks that must be carried out in each iteration of the software project to ensure its proper functioning, The agile methodology has been recently extended into several branches, and the most popular extension can be attributed to the Scrum framework [20].

2.1. General description of the method

Explains in This article that Scrum allows the creation of self-organized teams connected with all team members [21]. The verbal communication must prevail between all members and disciplines involved in the project, also it is required that the group can have feedback from the leader who is the Scrum master. Roles in Scrum for optimal work:

- Product owner: he is the one who represents the stakeholders.
- Scrum master: the team leader and facilitator of the entire team.
- Scrum team: the team performs analysis, implementation, design, and testing.

Likewise, there are the following artifacts that the Scrum team and stakeholders use to detail the product under development, the actions to produce it, and the tasks performed during the project.

- Product backlog: it is the list of requirements and stories, as shown in Table 1.
- Sprint backlog: they represent activities within the given time.
- Release burndown: the document that measures the backlog.

Table 1. Distribution per sprint

No. Sprint	Functional requirements	Stories	Time estimated	Estimated points	Priority
SPRINT 1	RF01: the system must have a login interface, where you must enter a username and password to access the home of the mobile application.	H1	10	80	1
	RF02: the application must allow the registration and modification of users, as well as the assignment of roles for each of them.	H2	7	80	1
SPRINT 2	RF03: the mobile application must allow the registration of patient data (name, surname, identity document (ID), place of birth, date of birth, sex, and address) and save them in the database.	H3	9	80	1
	RF04: the application must allow through its interface to search for patients by (ID and name) and display the data.	H4	7	60	1
SPRINT 3	RF05: the application, through its interface, must allow the recording of data (sex, weight, height, pre-test questions, pre-diagnosis, and date) and registration in the database.	H5	9	80	1
	RF06: the application must allow through its interface to view the clinical history of the patients (history, name, surname, ID, place of birth, date of birth, sex, district, address, height, weight, and real diagnosis).	H6	8	40	1
	RF07: the application, through its interface, must allow editing the data of the clinical history and saving.	H7	6	20	2
	RF08: the application through its interface must show a confirmation message when updating and/or deleting.	H8	1	10	2

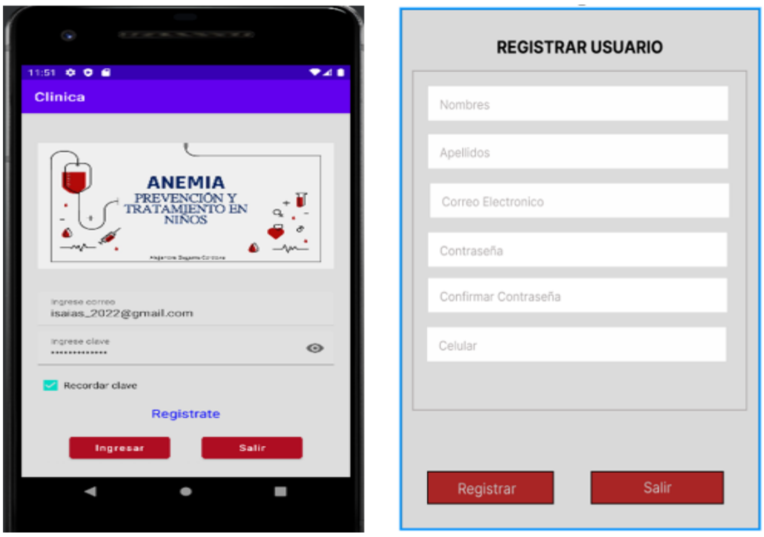
2.2. Sprint planning

2.2.1. Sprint 1

Functional Requirement (RF) 1: Figure 1, shows the interface to start and register the user. The system must have a login interface, where a username and password must be entered to access the home of the mobile application. You must also have a "remember password" check list in case the user lost the password. In the password section you will have a password display icon for the user. Finally, a "register" if the user will be new. Figure 1(a) shows the implementation of RF1, which is the login interface.

RF2: the application must allow the registration and modification of users, as well as the assignment of roles for each of them. Six sections must be created so that the user can register as a new user, in the password part you must confirm the password for security reasons. It will have "register" buttons so that the user can

register once everything is finished and the other "exit" button to finish the registration. The prototype to be made is shown in Figure 1(b), where the implemented application for user registration is shown.



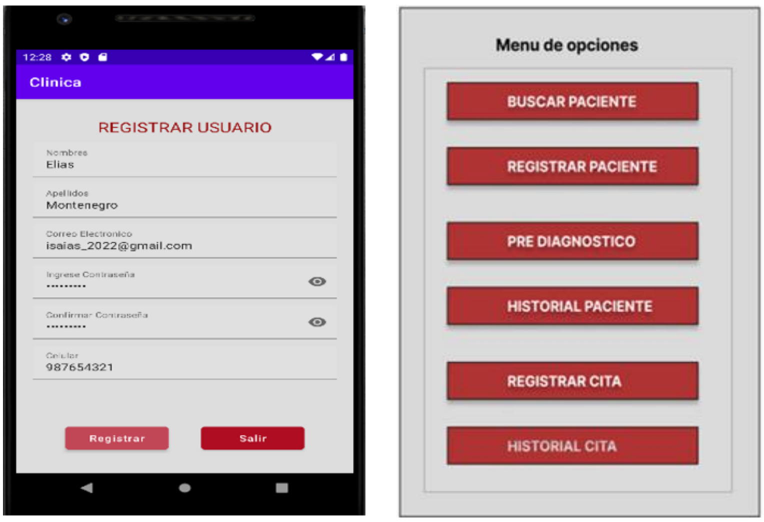
(a) (b)

Figure 1. Login and register the user: (a) the user has to register to log in and (b) the user registers

2.2.2. Sprint 2

In sprint 2, the goal is for the mobile application to be able to register patients with their corresponding data. Adding to that, you can also search for them in the menu options in Figure 2. You also have the option to cancel. RF3: the mobile application must allow the registration of patient data (name, surname, identity document (ID), place of birth, date of birth, sex, and address) and save them in the database.

RF4: The application must allow through its interface to search for patients by (ID and name) and display the data. In Figure 2(a) of the application interface, then there is Figure 2(b), which shows the "options menu" interface. Here are the buttons for the functions of quick patient search, record of a patient, pre-diagnosis, patient history, appointment record and appointment history, each time an option is selected, there is quick access to go back to the previous interface.



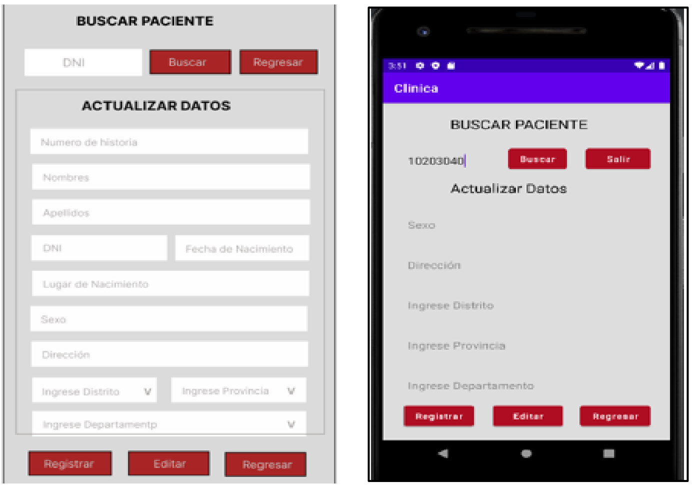
(a) (b)

Figure 2. Options menu: (a) the user enters his data and press "register" and (b) user displays menu option

2.2.3. Sprint 3

The objective of sprint 3 is that the application should allow through its interface to view the clinical history of the patients (history, name, surname, identity document (ID), place of birth, date of birth, sex, district, address, height, weight, and diagnosis real). Likewise, the power to edit this data and the confirmation and/or deletion of data, as shown in Figures 3 and 4.

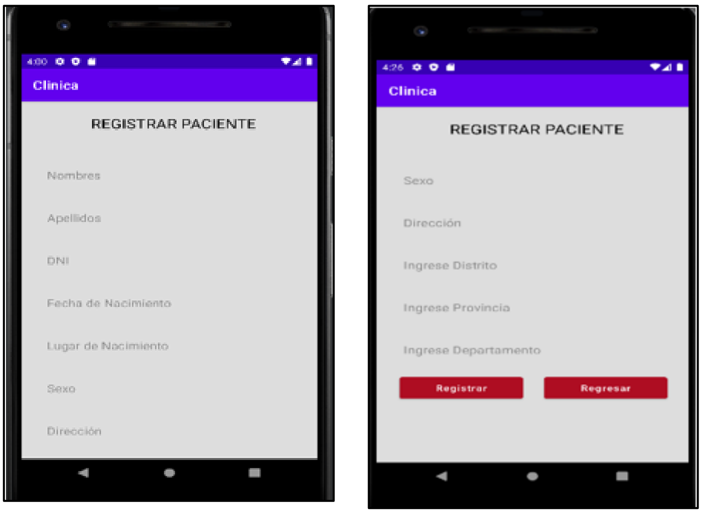
a. RF5: the application, through its interface, must allow the recording of data (sex, weight, height, pre-test questions, pre-diagnosis, and date) and registration in the database. Figure 3(a) shows the interface where the user/physician will have the option to search for a patient. In Figure 3(b) the registration button is if there is no registered patient; with the “national identity document” if a patient is found, the data will appear in the boxes, otherwise, a registrar will pass.



(a) (b)

Figure 3. Search patient design of RF5: (a)the update or search interface for the patient is displayed and (b) the patient is sought, otherwise it can be registered

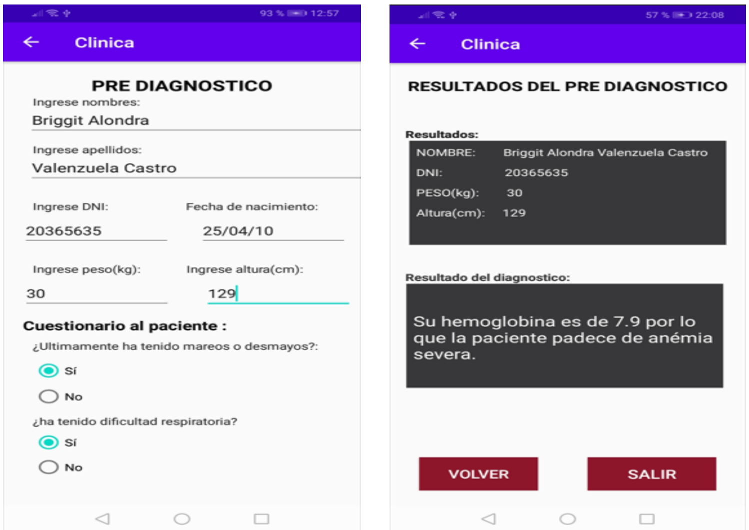
b. RF6: the application must allow through its interface to view the clinical history of the patients (history, name, surname, identity document (ID), place of birth, date of birth, sex, district, and address). Figure 4(a) shows that entering the patient's National Identity Document (DNI) could not be found. Then in Figure 4(b) it will go on to register, here it will ask for the patient's personal data so that it can be registered correctly.



(a) (b)

Figure 4. Register patient design of RF6: (a) the register patient interface is displayed and (b) to register the patient you must press "register"

c. RF7: the application, through its interface, must allow editing of the data of the clinical history and saving, Figure 5 shows the results of the pre-diagnosis. In this interface, as shown in Figure 5(a), the user will take a quick test, also called "pre-diagnosis", in which he will be asked for data such as names, surnames, ID, dates, weight, and height. You will be asked 3 questions that you will have to answer. Then in Figure 5(b) you will enter the "register" button and it ends with "see result" so you can see the result, there it will show you the data with your patient results.



(a) (b)

Figure 5. Pre-diagnosis and results design of RF7: (a) in the interface, the patient will make a diagnosis for the evaluation and (b) the interface shows the result that the patient gave after the evaluation

3. RESULTS AND DISCUSSION

3.1. Key performance indicator (KPI) 1: "time control"

Data were collected from 40 children who attended a clinic in Lima, Peru between August and December 2021, using a simple random sampling technique. The statistical results are shown below using SPSS software for each indicator. In this section, a descriptive analysis was carried out for the indicator "time control". The comparison was made between the levels of the time of medical control of anemia in children in times of pandemic, either pre and post, as shown in Table 2. Then the histogram was made for pre and post time control, where the frequency of time is from 1 to 9 hours as shown in Figure 6.

Table 2. Frequency of the indicator time control

		Time pre	Time post
N	Valid	40	40
	Lost	0	0
Mean		4.40	4.85
Median		4.18[a]	4.71[a]
Mode		4	4
Desvest		2.061	2.070
Varience		4.246	4.285
Sum		176	194
Percentile	25	2.69[b]	3.33[b]
	50	4.18	4.71
	75	6.18	6.36

Verifying the results presented in Table 2 and Figure 6, for the time control indicator, the average value was 4.40 in the previous test and 4.85 in the post-test. With this result, we can see an increase of 10.2%. Next, the normality test will be carried out as shown in Table 3. As shown in Table 3 the sig. of the pre-test is 0.027 and the sig. of the post-test is 0.209 of Shapirowilk where both values are greater than 5%, then it is stated that the data have a normal distribution. Then the contrasting of hypotheses was carried out with the Wilcoxon test. With respect to what is observed in Table 4 using the Wilcoxon non-parametric test,

a significance level was obtained that is equal to 0.02, which is less than 0.05, which is the referential value to accept the research hypothesis. For this reason, it is deduced that mobile application influences the time of medical control of anemia in children in times of pandemic.

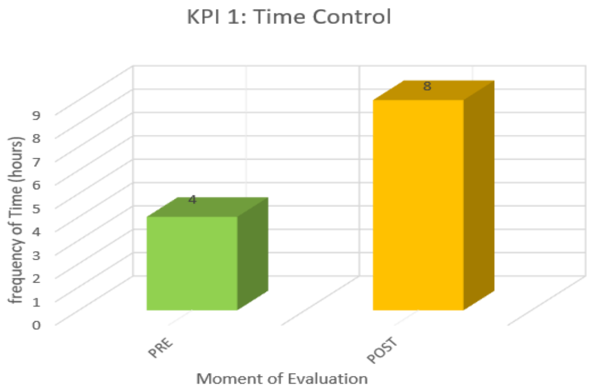


Figure 6. Histogram pre-test and post-test of the indicator “time control”

Table 3. Test normality of indicator 1

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Stadistic	gl	Sig.	Stadistic	gl	Sig.
PRE	0.152	40	0.021	0.937	40	0.027
POST	0.159	40	0.012	0.963	40	209

Table 4. Wilcoxon test for the indicator "time control"

Test statistics[a]	
	Time control-pre-&-post
Z	-1.946[b]
Asymp. Sig. (2-tailed)	0.020
a. Wilcoxon signed ranks test	
b. Based on negative ranks	

These results obtained are similar to other research found [22] in the study of screening methods based on photographic images with a digital camera; in which photographic images of the patient's nails were used to determine if the patient has a percentage of probability of having anemia, to predict anemia neural network was used, having results as in Table 3, in the case of sensitivity 0.79 and the specificity of 0.91, this shows that the evaluation time goes from 15 minutes to 1 minute, the evaluation which is similar to the results obtained from Table 2 in terms of time. Likewise, research by Rivero-Palacio *et al.* [23] mobile application for anemia detection through ocular conjunctiva images, showed results that the application had a sensitivity of 0.71 and a specificity of 0.89 for predicting anemia and reduced the time from 10 to 1 minute contrasting with the research. However, in the research by Roychowdhury *et al.* [24] on computer aided detection of anemia-like pallor, using the machine learning algorithm, it was found to have an accuracy of 98.2% in detecting ocular pallor, to determine anemia. As for the time reduced to 1 minute, it implies that both the assistance by mobile application, computer, and the digital camera shows a reduction in the evaluations and maintains the similarity of data with the results of Figure 6 that time is a very important factor for the discards of childhood anemia.

3.2. Key performance indicator (KPI) 2: "number of diagnoses"

In this section, the analysis of the "number of diagnoses" indicator was carried out, which made a comparison between the number of diagnoses between pre and post, as shown in Table 5. Then the histogram was made for pre and post number of diagnoses, the diagnostic score goes from 1 to 10 as shown in Figure 7. Verifying the results presented in Table 5 and Figure 7, for the indicator number of diagnoses, the average value was 4.95 in the previous test and 6.60 in the post-test. With this result, we can see an increase of 33.3%. Next, the normality test will be carried out as shown in Table 6. As shown in Table 6 the sig. of the pre-test is 0.043 and the sig. of the post-test is 0.027 of Shapirowilk. Where both values are greater than 5%,

after having analyzed it, it is affirmed that the data have a normal distribution. Then the Wilcoxon test was performed for indicator 2. With respect to what is observed in Table 7, using the Wilcoxon non-parametric test. A level of significance equal to 0.00 was obtained, which is less than 0.05, the limit value for evaluating whether the research hypothesis is accepted. After having analyzed, it is observed that the p-value is less than 0.05 and this means that the mobile application positively influences the diagnosis of anemia in children in times of pandemic.

Table 5. Frequency of "number of diagnoses" indicator

		Diagnoses pre	Diagnoses post
N	Valid	40	40
	Lost	0	0
Mean		4.95	6.60
Median		4.69[a]	6.40[a]
Mode		4	7
Desvest		2.062	2.629
Varience		4.254	6.913
Sum		198	264
Percentile	25	3.44[b]	4.89[b]
	50	4.69	6.40
	75	6.30	7.79

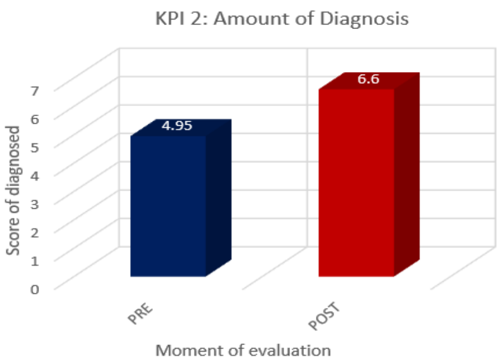


Figure 7. Histogram pre-test and post-test of the indicator “number of diagnosis”

Table 6. Test normality of indicator 2

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Stadistic	gl	Sig.	Stadistic	gl	Sig.
PRE	0.177	40	0.003	0.943	40	0.043
POST	0.165	40	0.008	0.937	40	0.027

Table 7. Wilcoxon test of indicator 2 "number of products sold"

Test statistics[a]	
	Number of diagnoses-pre-&-post
Z	-4.321[b]
Asymp. Sig. (2-tailed)	0.000
a. Wilcoxon signed ranks test	
b. Based on negative ranks	

Research by Mohammed *et al*. [25] which studied the analysis of anemia by data mining, it is explained that 4 methods were applied for the measurement, of which logistic regression (LR) and multilayer perceptron (MLP) showed 87.3% and 87.1% efficiency, respectively, in contrast to other results. Research by Kobayashi *et al*. [26] the study examination of anemia using a hyperspectral camera, gave results of two measurements at the level of pigmentation that bands 510-600 nm. Unlike others, research by Tamir *et al*. [27] showing severe anemia, the detection of amenia from the image of the anterior eye, in the noninvasive procedure taken with a smartphone camera that detects conjunctival pallor, gave a result with an accuracy of 78.9%, whereas the results of [25] are more accurate and closer to our results. On the contrary, according to Jayakody and Edirisinghe [28] mobile application for the detection of anemia based on

autonomous learning with neural networks entails that the user must answer a questionnaire in which he obtains an approximate result, maintaining the similarity of discard and acceleration with the presented study, unlike the study [29] to determine the morphological classification of anemia based on algorithms that classify the type of sickle cell disease through machine learning generating an average probability of detecting the type and accelerating the diagnosis as in Table 6.

3.3. Key performance indicator (KPI) 3: "performance control"

In this section, a descriptive analysis was carried out for the "performance control" indicator, a comparison was made between the measurement of anemia control performance in time before and after implementing the mobile application, as shown in Table 8. Then the histogram was made for pre- and post-"performance control" as shown in Figure 8. Verifying the results presented in Table 8 and Figure 8, for the performance control indicator, the average value was 0.45 in the previous test and 0.78 in the post-test. With this result, we can see an increase of 73.3%. Then the contrasting of hypotheses was carried out with the McNemar test. Regarding what is observed in Table 9, the non-parametric test for qualitative variables is analyzed: McNemar. In which a significance level was obtained that is 0.01 which is less than 0.05, limit value to evaluate if there is acceptance of the research hypothesis.

Table 8. Frequency of "performance control" indicator

		Satisf. Pre	Satisf. Post
N	Valid	40	40
	Lost	0	0
Mean		0.45	0.78
Median		0.45[a]	0.78[a]
Mode		0	1
Desvest		0.504	0.423
Varience		0.254	0.179
Sum		18	31
Percentile	25	.[b,c]	0.28[c]
	50	0.45	0.78
	75	0.95	.

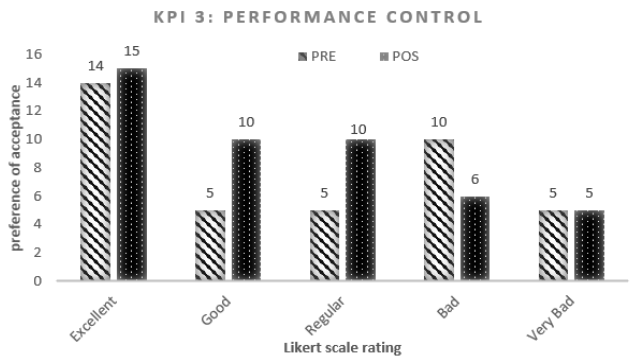


Figure 8. Frequency of the indicator performance control

Table 9. McNemar test for the indicator "performance control"

Test statistics[a]	
	Performance control-pre-&-post
Z	41
Exact sig. (2-tailed)	0.01[b]
a. McNemar test	
b. Binomial distribution used	

This contrasts with the results found Hafeel *et al*. [30] with the internet of things (IoT) device to detect anemia by the intensity of red blood. Using for the evaluation a server that receives both the sample and the questionnaire, an accuracy level of 83% was achieved in ruling out anemia. While in the study Ghosal *et al*. [31] based on smartphone spectroscopy to monitor blood color by conjunctival pallor; the model shows a sensitivity of 89% effectiveness. therefore, the application is reliable and contrasts with our findings in Figure 8 and Table 9.

4. CONCLUSION

Based on the results obtained after having analyzed the tests imposed, we conclude that the medical control time can be faster in the attention and this has favored a more fluent control. In other words, it has generated a greater number of patients seen during the day, thereby achieving the proposed objectives and satisfactorily responding to the hypothesis, which had an increase of 10.2%. On the other hand, the mobile application has greatly influenced the process of diagnostic control of anemia in children, since it has allowed greater control in the registration and follow-up of the recovery of children with anemia. indicates that the hypothesis raised has been satisfactorily, which had an increase of 33.3%. Finally, regarding the performance of the application against the pandemic, it can be concluded that it played an important role in terms of streamlining care processes, and diagnoses, among others. It is contrasted with the measurements, which had an increase of 73.3% effectiveness. It is recommended to use this type of technological tool for the registration and control of diseases in times of pandemic given the positive results.

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